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Transforming the Uranium Fuel Cycle: Safe & Economical Conversion of DUF_6 to DUF_4

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The goal of this rapid response project was to show that DUF_6 can be converted to DUF_4 using hexamethyldisilane (HMDS), producing trimethylsilyl fluoride (TMS-F) as a by-product. These would represent a significant improvement in the safety and economy of the current DUF_6 to DUF_4 downconversion, which produces HF as a by-product. Currently, there are over 700,000 metric tons of DUF_6 within the DOE complex that are being stored largely in cylinders at plants near Portsmouth, OH and Paducah, KY, and due to the corrosive properties of HF being slowly created from the DUF_6 these cylinders are corroding, representing a massive public health risk. The DOE has stated that if a safer, more economically viable method than the current process were discovered, it would strongly consider implementing it. Initial efforts at probing whether DUF_6 will react with HMDS to produce TMS-F showed that while using a solvent (toluene or pyridine) in this reaction, the solvent was fluorinated by the DUF_6 rather than the HMDS, which is not the predicted outcome but still shows that simple organic solvents can help to downconvert DUF_6 to DUF_4. When using no solvent (i.e. a “neat reaction”) with HMDS, it appears as though a reaction occurs to give various fluorinated silanes, but not TMS-F, indicating that the DUF_6 is more reactive with the HMDS than anticipated. This complicates the potential separation of useful commodity fluorosilanes, but we anticipate with proper distillation columns separations of these chemicals will be possible. While we have yet to find an effective way to utilize HMDS to convert DUF_6 to DUF_4, we have seen encouraging results. Additionally, we have ironed out many technical details of doing work at LANL, such as writing an IWD and getting the new activity approved, and how samples would be transferred from TA-48 to the Sigma complex. This will enable much faster and more efficient future research in this area and others that can combine the technical expertise of staff in C and Sigma division, a collaboration that will bring together scientists and staff with complimentary skillsets and capabilities.

Figure 1: DUF_6 loop used for the reactions in this study.

This activity is tied to the LDRD funding mission in several important ways. If this technique can be developed to the point of working at scale, this could fundamentally change how the DOE complex handles the DUF_6 challenge that it faces. We believe this is a high-risk/high-return technology that, if effective, would also help to secure the DU needs of the nation for decades to come. This new approach would greatly enhance our mission agility by providing an innovative solution to both enhance the safety of our DUF_6 storage issues and DU supply generally. Finally, this project has allowed for a pathway to conversion for Justin Pagano, a post-doc working on the project, who is learning mission critical skills such as proper DUF_6 handling and other related techniques. The ability to handle DUF_6 is becoming a lost art, and enabling talent in learning skills such as this provide a pipleline to conversion at labs like LANL where the work being done is often unique.